Internet Objects for Building Control

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Position paper

Trends in building control market

In building control market two networking technology trends are taking place: (1) Integration of building control, and (2) Introduction of wireless networks.

Integration of building control: building control networks today are composed of several independent silos like: (1) Heating, Ventilation and Air Conditioning (HVAC), (2) Fire control, (3) access and intrusion, and (4) Lighting and shutters. Each of these silos has its own networking standard and is installed and operated in isolation. The increasing wishes for comfort, energy reduction measures, and maintenance cost reduction, force the connection of these networks and the execution of applications over a set of silos. The cost of the installation and operation of the networks promote the integration of the silos with one networking standard. The most likely standard to be employed is the Internet standards given the large set of available off-the-shelf products.

Introduction of wireless networks: for the retrofit market (larger part of the total building control turn-over), the deployment of wireless networking is rather attractive, because it avoids the laying of cables and installing new cable ducts in existing buildings. Also the need to provide more sensor input to regulate the climate parameters in accordance with advanced comfort, health and energy objectives, promotes the installation of more wireless sensors. Being wireless gives a higher degree of topological installation independence with respect to already installed cable ducts.

The wireless devices need to operate on a single battery or need to be powered by energy scavenging. This requirement has led to a plethora of wireless low-resource standards like ZigBee, Z-Wave, Wireless hart, IEEE 802.15.4, etc. The advent of the IETF 6LoWPAN working group has made it possible to transport Internet packets over the wireless medium between low-resource nodes.

Success in the building control market is very much price driven. Therefore, two forces make it likely that low-resource nodes are there to stay a long time: (1) the price pressure makes the industry look for cheap devices where every unnecessary mm^2 in chip surface is removed, (2) improved energy management in battery-less devices leads to devices with increased availability and easier installation procedures at the cost of memory size and CPU power.

Although a point may be reached that the increase in 100s of kBytes does not affect the price of the chip, it is our belief that this is still far removed from the reality the coming ten years and low resource devices are introduced into Internet to stay.

Mapping Internet of Things to building control

The “Internet of Things” (IoT) is a metaphor for software objects associated with physical devices which communicate over an open world-wide network: the Internet. The metaphor subsumes a high flexibility

in the deployment and installation of the “things” within the network. Plug and play does not even touch the subsumed flexibility, because “things” are assumed to appear and disappear at will and at appearance time to be able to converse with other “things” which are at conversation distance.

This level of autonomous behavior is not entirely encouraged in the professional building domain. A strict requirement is that all specified devices are present and no others. A controlled installation of the objects is important in this context. However, the attributes to function in isolation and to be able to communicate and interact with peer devices are very much needed. The similarities between the IoT metaphor and the devices constituting the building network can be summarized:

- After installation in the network, devices need to know their function (e.g. the wake-up light in the blue room).
- Devices need to collaborate with peer devices.
- Devices need to distinguish between neighboring devices within or out of reach to determine the communication partners from an application point of view.
- Presence and absence of devices need to be known in the network.

Aspects which are not immediately associated with IoT are:

- Devices need to converse with legacy devices (install base).
- Devices need to be grouped in services where the grouping of host services provides a new higher level service.

Things communicate with each other without human intervention. The exchange of messages can therefore be very terse. Objects need to establish which language is exchanged but do not bother about visual presentation of the information.

Internet standardization

For building control there is clear scope of standardization with Internet. The industry profits from the presence of many reasonably priced commodity equipment that can interoperate at the transport level. The wishes on the Internet standardization by the building control community are not always aligned with the current practice within Internet. It is important that both worlds – the Internet community and the real-time control community - try to understand each other’s problems and solutions. The Internet community has a large experience with large scale (almost) uncontrolled proliferation of networked devices. The real-time control community is used to working with closed networking structures with elimination of the probabilistic aspects.

Going for the IoT paradigm has profound consequences for the building control industry. Associating with a connected device one or more objects has as consequence **all-IP** to all levels of building control. On the one hand this means a larger market because the costs of building control becomes affordable for a larger set of buildings; on the other hand many new players on the market can build Internet applications for building control.

A major difference of insight between Internet and building control view is the concept of *local.* The building control network is hybrid: wired and wireless. For installation and maintenance the network is cut up in hybrid *segments*: wired can be used for lamps and valves, while wireless is more appropriate for light switches sensors and thermostats. In this hybrid network the network organization in routers, bridges, and switches does not map directly to the units of control and installation. One room may consist of a wired segment and a wireless segment. A local network is composed of several network links and thus composed of multiple link-local segments. Currently, the following problems can occur:

- *Installation.* Installing devices will be executed on several segments without connection to infrastructure servers like DNS or DHCP. Use of IPv6 stateless auto-configuration (SLAAC) seems to be more appropriate but cannot be deployed without proper pre-existing routing infrastructure in place to inter-connect segments.

- *Group communication*. Several devices are grouped and must receive the same set of commands in the same order. Proprietary multicast algorithm as developed in the real-time literature may well cover the requirements. However, the groups are connected by a hybrid segment and the multicast may pass over routers (e.g. 6LBR). It is difficult to specify the scope of the multicast messages over the hybrid segment (how many routers must the message pass, and how to handle duplicates). The writing of an informational RFC on real-time multicasting is recommended.

- *Routing* over one large wireless network is not common, but routing takes place over hybrid, possibly small segments. The wireless ranges of nodes in different segments can overlap. Reliability is important. Therefore, when one wireless node (in or outside the segment) has received a message, the message should be routed on to the final destination. This is a problem actually because the node outside the segment will receive the message but reject it as not being the router of the message.

Another major difference of insight between Internet and building control view is the appreciation of cost of communication. After painstakingly removing bytes in the packet headers, all of the sudden large *url* strings are transported and the verbose *xml* is suggested as application language. Such a wish is completely in agreement with current practice on the Internet but defeats the purpose of the 6LoWPAN and CoRE working groups which is targeted to low-power devices. As pointed out above, the market forces for buildings differ from the ones usually valid on the Internet. New features in building devices need to bring additional financial advantage in relation to the cost and installation price of the device. Accordingly, a heavy pressure on the cost price will force programmers not to follow their wishes but to conform to limits.

The accompanying question is how to integrate the existing commodity verbose internet applications with the terse “things” to “things” applications. Already suggestions are done to compile xml into a table form. The suggestion is to include in http-coap proxies standard syntax rules to convert xml to tables and vice-versa.